Fitting of Auger Electron and Secondary Electron Line Scans with the Extended Logistic Function

NIST researchers have expanded on an extended form of the logistic function that was proposed by Kirchhoff, Chambers and Fine, and applied it to line profiles of both secondary electrons and Auger electrons. This capability may have its greatest impact in the measurement of instrumental resolution. A Windows-compatible software implementation of the logistic function is being developed at NIST is currently being tested and will be made available to the user community through the NIST website.

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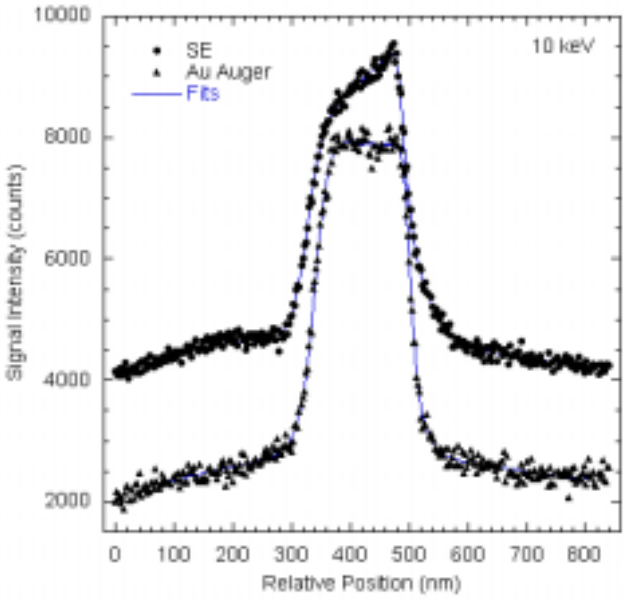
Auger-electron spectroscopy (AES) is used for surface analysis and for determining variations of composition from one phase to another in an inhomogeneous specimen. A common application of AES has been the determination of composition as a function of depth in thin-film specimens by sputter-depth profiling. Additionally, the scanning Auger microscope (SAM) is also used to analyze heterogeneous samples with line scans which are the measurement of chemical composition along a line on the sample surface.

Kirchhoff, Chambers and Fine [J. Vac. Sci. Technol. A **4**, 1666 (1986)] proposed the use of an extended form of the logistic function to describe compositional changes between two materials as a function of depth from an AES sputter-depth profile. This approach was found to be a convenient means of objectively determining parameters describing the interface width and possible asymmetry of the profile.

We have expanded upon this work by applying the logistic function to line profiles of both secondary electrons and Auger electrons. This capability may have its greatest impact in the measurement of instrumental resolution. Currently, secondary electron imaging of gold islands on carbon is the standard test for secondary-electron imaging resolution in electron microscopes. The Au-island images are routinely indexed manually to determine the instrument resolution.

The NIST team fitted Auger-electron (AE) and secondary-electron (SE) line scans from two types of specimens with the logistic function. The fits for a gold island on a carbon substrate provided useful measures of lateral resolution in our SAM (values between 22 nm and 34 nm compared to a specification of 19 nm at these conditions) and showed clear evidence of "tails" associated with imperfect alignment (Figure 1).

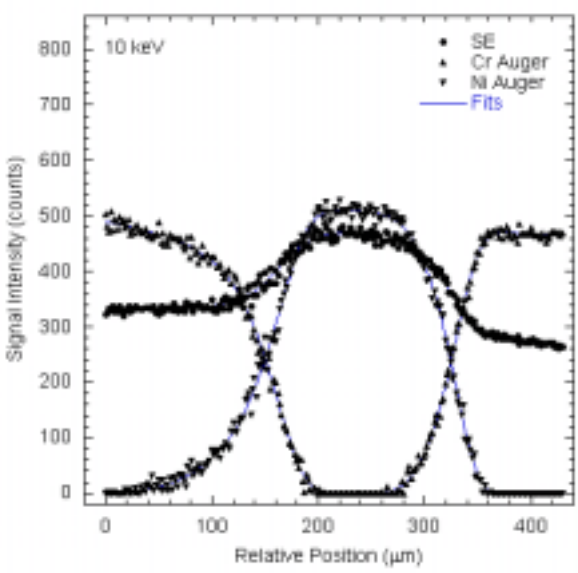
Figure 1: Example fits with the logistic function to secondary electron and Auger-electron line scans across a gold island measured with primary beam energy of 10 keV.



With the higher resolution of today's electron microscopes, the manual determination of the resolution relies upon a subjective selection of the edges of the gold particle to determine if an instrument is operating within specification. Unlike manual fitting, the logistic function provides objective measures of the position, width and possible asymmetry of an interface.

An analyst might wish to minimize the magnitude and range of these tails while aligning a SAM to maximize beam current and minimize the beam width. We also used the logistic function to fit SE intensities of a fractured Ni/Cr multilayer sample and SE and AE linescans across a sputtered crater of this sample (Figure 2). The fits using the logistic function gave useful measures of the interface width (the average value is 23.3 μm).

Figure 2: Fits with the logistic function to Ni and Cr Auger-electron and secondary-electron line scans across an edge of a sputter crater of a Ni/Cr multilayer measured with a primary beam energy of 10 keV.



Future Plans:

A software implementation of the logistic function is being developed. This Windows-compatible software, currently in a beta test phase, will conveniently estimate the position, width and asymmetry of an interface between two dissimilar materials. This software will be disseminated through the Surface and Microanalysis Science Division web page.

Publication of results:

SA Wight and CJ Powell **"Evaluation of the shapes of Auger- and secondary-electron line scans across interfaces with the logistic function"** *Journal of Vacuum Science and Technology* A, 24(4), 1024, Jul/Aug 2006.